How should elementary school students construct their knowledge in mathematics based on Bruner's theory?

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How should elementary school students construct their knowledge in mathematics based on Bruner's theory?

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Abstract. Elementary school teachers should know how their students construct a very abstract concept of mathematical knowledge. Elementary school children are still at the concrete operational stage, while the characteristic of mathematics itself is abstract. This study is descriptive qualitative research. Data collected by observation and documentation. The study describes how Elementary school students should build their mathematical knowledge based on Bruner's Theory (enactive, iconic and symbolic stage) and how mathematics learning process provided by Elementary school teachers.

1. Introduction

Understanding student's mathematical thinking can provide coherence to the ability of teaching mathematics. Children enter school with a great informal or intuitive knowledge of mathematics that can be used as a base to develop the formal mathematics of the elementary school curriculum [1]. Intuitive knowledge is important for children learning and it is a concrete model [2]. In Indonesia, elementary school students are children whose age ranges between 7 and 11 years old. According to Piaget's theory they are classified in the operational concrete level [3]. Based on observation in many elementary school in Kudus, the learning process in mathematics is still presented by teachers using abstract mathematics. The patterns are: 1) teachers give mathematics concept or knowledge (in abstract condition), 2) teachers give examples, and 3) students do the exercises. Many students feel stuck and meet the deadlock when the exercises or problems have different patterns from the examples. This condition is not appropriate for elementary students' cognitive level that is still in the operational concrete stage. So many elementary school students in Kudus have negative perspective and anxiety towards mathematics. They just know that learning mathematics is memorizing the formula or concepts, paying attention to the examples and doing exercises. This view may not be held by the elementary school students at big cities like Jakarta, Surabaya, Yogyakarta, and Semarang, who have better facilities and higher awareness to education. From this condition, it is very hard for elementary school students in Kudus to develop their higher order thinking skills, like reasoning, creative thinking, critical thinking and problem solving. This study attempt to give some ideas about how elementary school students should learn and construct mathematics knowledge and how learning strategies should be given to them.

2. Research method

The type of this research is descriptive qualitative study. Data collected by observation and documentation. Students at elementary school at SD 1 Kaliputu Kudus are the source of data. Triangulation of the sources and triangulation methods used for validation data [4]. The data is analyzed by using interactive analysis techniques, consist of data collection, data reduction, data presentation, and conclusion and verification.

3. Results and discussion

The result output shows that students at SD 1 Kaliputu can construct mathematical concepts using Bruner's theory principle by using kite's manipulative media.

3.1. Constructivism

Constructivism is a psychological and philosophical perspective that views each individual forms or builds most of what they learn and understand [5]. In constructivism students constructing historically that achieved conceptual structures from their ingenuous notions [6]. Constructivism theory suggests that children must be active in building and developing their understanding. It gives us insight into how children learn math and guides us to use teaching strategies that starts by considering students' condition, instead of paying attention to our condition (teacher). The basic principle of constructivism is that children construct their own knowledge. The more ideas being used and the more relationships being made, the better we understand. To construct new knowledge, active thinking is required regarding that knowledge. It is good to know how this knowledge matches the knowledge we already know [7]. The process of understanding can be seen in the figure 1.

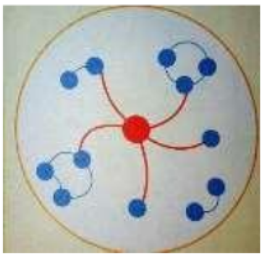


Figure 1. Construction of new ideas/knowledge.

We use the ideas we have (blue dots) to construct new ideas (red dots) that is, by developing relationships between ideas. Understanding is defined as a measure of the quality and quantity of an idea relationship with an existing idea. The more number of relationships in the network of ideas, the better understanding it would be. The idea network of each child is different from others, when new ideas are formed, they will be integrated into the network of ideas in a unique way. In order for children to create new ideas and connect them with the network of ideas, they must be involved to think. Although learning is a reflective and internal process, children can test reveal, modify and develop new ideas through interaction with other children and teachers. This can attract children into their Zone Proximal Development (ZPD) and support the development of understanding significantly. The level of understanding varies. Understanding depends on the appropriate idea you have and depends on creating new relationships between ideas. The peak of understanding contains a great deal of relationship. Understandable ideas is associated with many other ideas by meaningful network concepts and procedures. Skemp explains that mathematical concepts should be considered with better understanding [8]. Skemp classifies there are two types of understanding: 1) instrumental (separate ideas without meaning, engaging mathematical procedures accurately and efficiently but not knowing why) and 2) relational understanding (network of rich ideas, knowing both what to do and why) [9]. Piaget posits that the implications of cognitive development in learning are: 1) understanding student's cognitive

development of students, 2) keeping students active, 3) creating discrepancies so students think, and 4) providing social interaction [10]. For elementary school students constructivism is important for learning mathematics

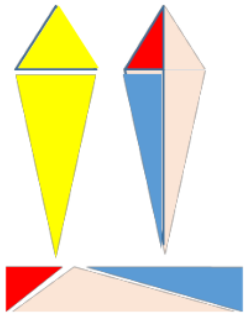
3.2. The construction of mathematical knowledge based on Bruner's theory

The construction of knowledge is an active process, not a passive process [11]. Bruner argues that children construct their knowledge through three modes, they are: 1) enactive (actions, real word), 2) iconic (images and pictures), and 3) symbolic (words and symbols) [12]. The construction and discovery of mathematical knowledge can adopt the Bruner theory (enactive, iconic and symbolic). Bruner in states that these stages are a cognitive process of human learning [13]. Construction of mathematical knowledge based on meaningful experiences for students is a part of mathematical thinking [14]. Some research shows that manipulations by using concrete or manipulative media then represented graphically (drawn), and carried out symbolically according to Bruner's stages of representation (enactive, iconic and symbolic) [15]. For the example student's mathematical construction on square and rectangle's area can be use Sarong motive Chess as manipulative media [16]. Moreover, in Singapore, The Concrete-Pictorial-Abstract (CPA) approach, based on Bruner's conception of the enactive, iconic and symbolic modes of representation, is a well-known instructional heuristic advocated since early 1980's [17].

3.3. The implication in mathematics learning process for students at SD 1 Kaliputu Kudus

Mathematics learning process at kite's area for students at SD 1 Kaliputu begin using kite's media as an effort to involve the student in an active way in the learning process. This step is enactive stage. For the next step the teacher use kite's manipulative media for student's mathematical construction, students can build kite's area by two area approach, they are triangle's area and rectangle's approach. This step is iconic stage. And for the last step is symbolic stage. Table 1 below presents student's mathematical construction at SD 1 Kaliputu Kudus based on Bruner's Theory.

Table 1. Student mathematical construction (learning kite).

Enactive stage	***Iconic stage***	***Symbolic stage*** (Withdrawal of conclusions in the form of mathematics symbols)
 **Kite (as concrete situation)**  **Kite (as manipulative props)**	 **Picture Representation**	The area of kite = the area of rectangle = $l \times w$ = $d_1 \times \frac{1}{2} d_2$ The perimeter of kite = the number of the sides

4. Conclusion

Elementary school students should construct their own knowledge in mathematics. They can use their previous knowledge to construct new knowledge. They can use a concrete model from their own

previous knowledge as a starting point to build new concepts in mathematics. Elementary school teachers should build situations in such a way that students can engage actively and interactively in mathematics learning process through the construction of mathematical concepts. It can be done by thinking of appropriate concrete level situations toward formal abstract mathematics. Among others, a teacher can adopt Bruner's theory (enactive, iconic, and symbolic) to help their students construct their own knowledge in mathematics.

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PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5